



A CBT PUBLICATION

HOW IT WORKS

THE AEROPLANE

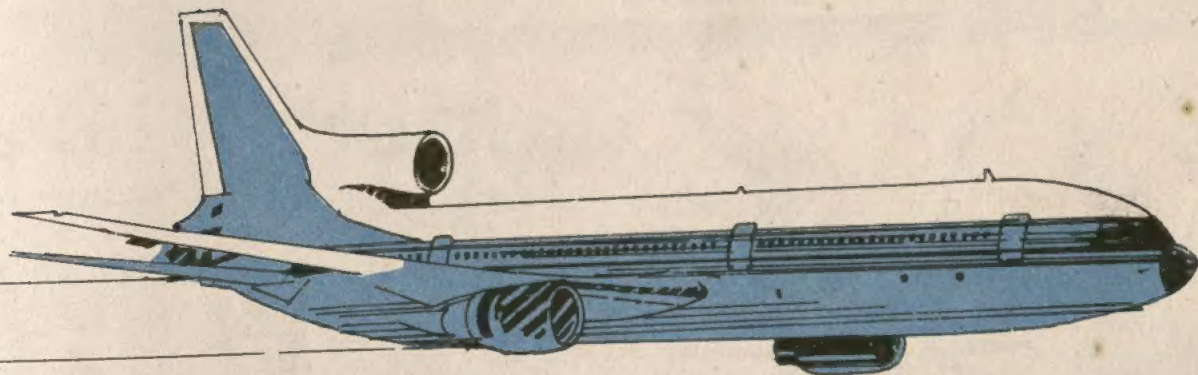


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THE AEROPLANE HOW IT WORKS

BY NAVKALA ROY ■ DESIGNED AND ILLUSTRATED BY SUBIR ROY

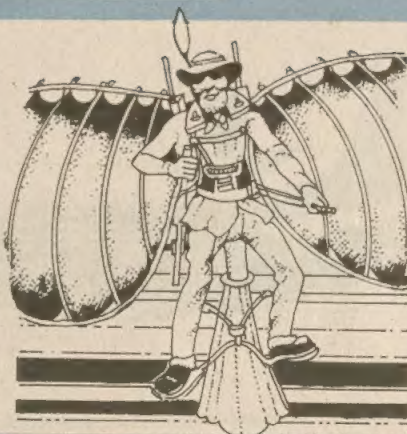
An idea takes shape...



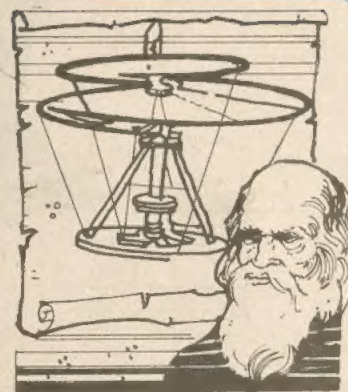
Garuda—Indian mythological bird



Icarus—from Greek mythology

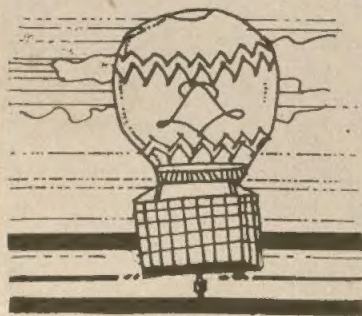


Man's first attempt at flying (1020 A.D.)

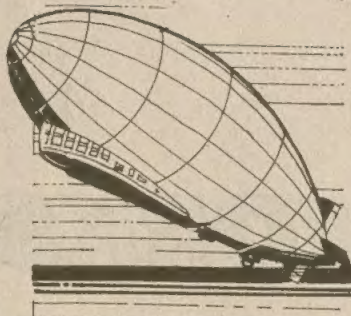


Flying machine designed by Leonardo da Vinci (1505)

Hot-air balloon (1783)



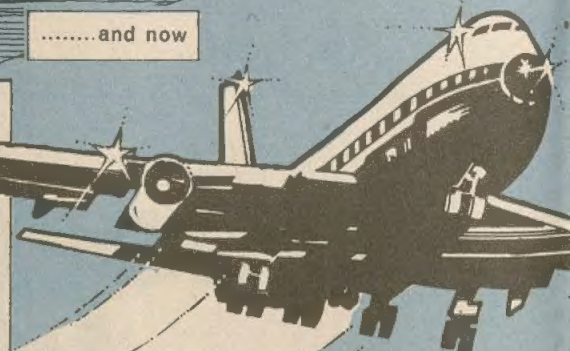
Airship (1852)



Wright brothers—inventors of powered flight (1903)

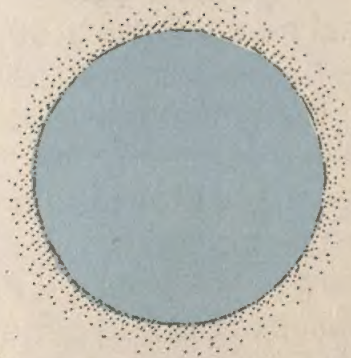


.....and now



..and takes off...

Acc. no - 15211



Up above the world so high
Like a big bird in the sky....



It's so unreal. At the same time so fascinating. This gigantic bird that man has invented—the aeroplane.

Unlike an automobile, a train or a ship, it breaks all barriers as it speeds along, sometimes faster than the speed of sound, across the limitless sky.

To man, the aeroplane was a symbol of freedom. In ancient Hindu mythology it was Garuda—the great celestial bird who is said to have 'mocked the wind with his fleetness.' And in Greece it was Icarus who is supposed to have risen from the earth on wings of wax and flown until he came so close to the sun that his wings melted.

Perhaps it had always been man's secret desire to compete with the birds. To glide gracefully in the air. To break free from the earth. To soar over the mountains and the seas. The aeroplane is in fact, a dream come true.

Try try again

Many daring men tried to construct wings for themselves before the plane was invented. One such was Oliver of Malmesbury, an English monk. He wore a pair of thin wooden wings across his shoulders, fixed a steering to his heels and went flap, flap from the tower of Malmesbury Abbey, till he flopped right down and almost broke his crown! But that did not stop others from trying. Infact, it was try, try again that finally worked. One person who contributed to the theory of flight is Leonardo da Vinci. What's a painter got to do with planes? Well, Leonardo's designs showed that muscle-power was not sufficient to fly. It needed certain mechanical devices before flight could be possible.

But even this suggestion was of no help to anyone for about 450 years. No one could imagine that one day it would be possible to get off the ground and stay there.

Up goes the balloon

Fancy travelling in a balloon. It seems as remote as travelling on a magic carpet. Yet, the first time that man left the ground by a craft, he sat in a basket attached to a balloon. Bigger than the ones you play with of course!

Two Frenchmen, the Montgolfier brothers, made this possible.

One day, sitting by the fireside, they noticed little pieces of burned paper rising in the air. 'If only we could trap enough of that gas produced by the burning fire', they thought, 'then we could use it to lift even men off the ground'.





The Montgolfier hot-air balloon

To begin with they held a small silk bag over an indoor fire, open end downward. Then they let go. It rose quickly to the ceiling.

In September 1783 they invited the King and Queen of France to a demonstration of their craft in the palace garden. For this occasion they buttoned together some linen panels and made a huge balloon, 38 feet in diameter. They lined it with paper to make it airtight. Then they filled it out with a gas from a fire of wool and straw and released it. The balloon, believe it or not, went up to a height of more than 1,800 metres before it landed a kilometre or so from its take-off point.

The Montgolfiers became heroes instantly. After all they had created the first aerial vehicle.


The first successful human flight in a balloon was from Paris in 1783.

Ballooning soon became a sport and a spectacle all over the world.

Sir George Cayley, an Englishman, tried to improve on the balloon by suggesting the use of a streamlined gas-bag. He introduced steam driven propellers for steering it. But it was not until 1850 that such a craft was built. It was called an airship.

Two people associated with airships are a Brazilian, Alberto Santos Dumont and a German, Count Ferdinand von Zeppelin. But airships, as it turned out, were slow and the hydrogen gas which made them float caught fire easily.

In 1937 the huge transatlantic airship 'Hindenburg' exploded in flames over New York. With this ended the life of airships.



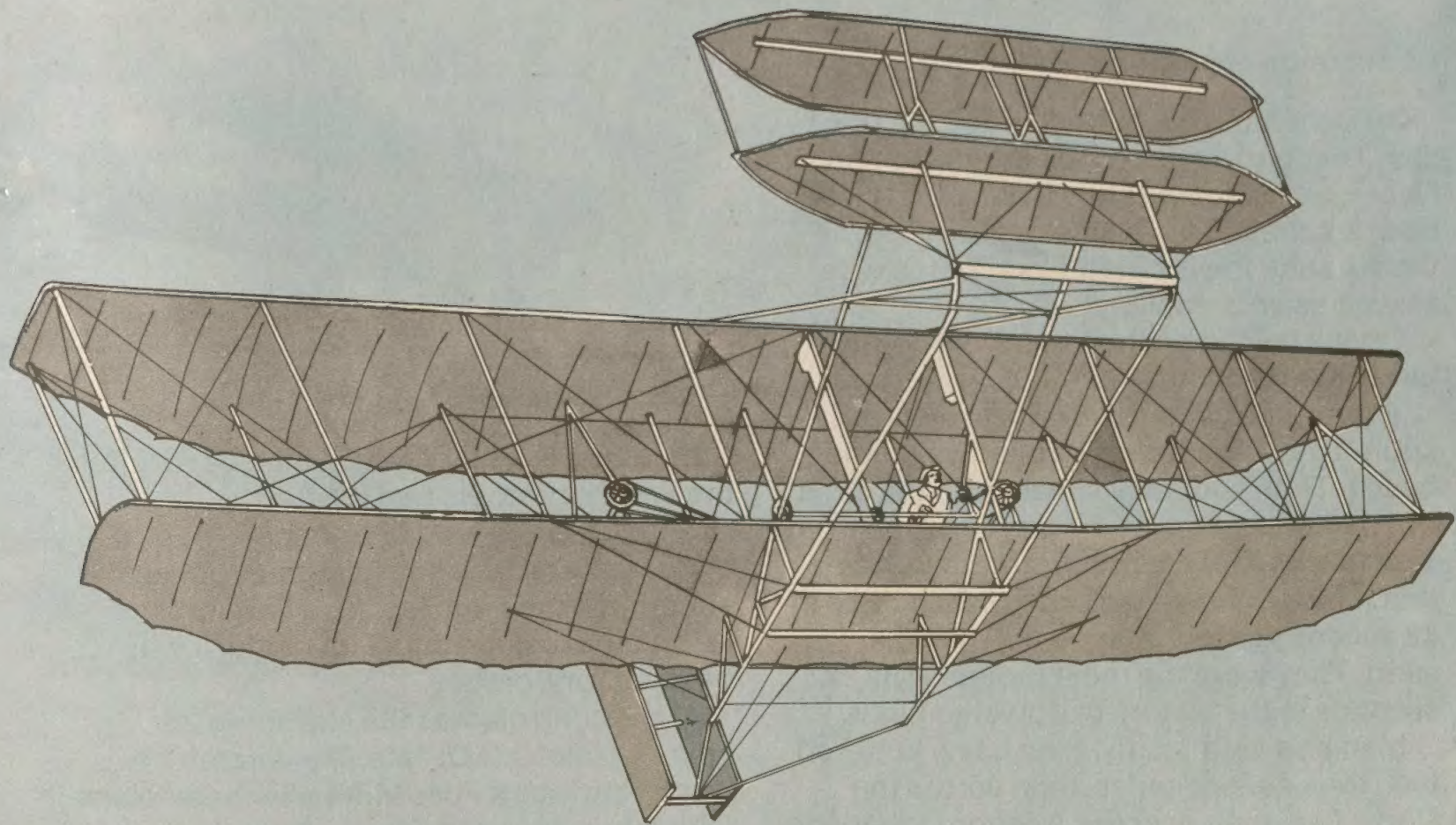
The airship 'Hindenburg' had a dining room 4.5 metres by 15 metres for her 70 passengers. The classic Hindenburg lunch over the Atlantic was—Indian swallows' nest soup, caviar and Rhine Salmon, lobster, saddle of venison, fruit and cheese.

Those magnificent boys

The brains behind the more familiar heavier-than-air aeroplane that we see today were two boys—Wilbur and Orville Wright. They weren't extraordinary. Just persistent and dedicated. One day their father brought home a toy aeroplane. It was made of bamboo, cork and paper and driven by rubber bands. But it flew.

Wilbur and Orville, when they saw it, were determined to be the first men to fly. It was this determination that led them to build a flying machine in their bicycle shop.

Then, instead of holidaying in summer, they toddled off to Kitty Hawk—a deserted seacoast in North Carolina—to experiment with their craft. After thousands of trials and errors they were able to glide this machine made of sticks and cloth, controlling both up and down as well as sideways movement. Then they fitted an internal combustion engine and two propellers to it.



Flyer-I—the world's first powered flight

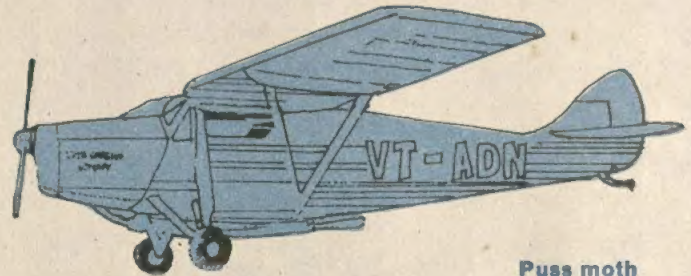
12 seconds that changed the world

On December 17, 1903 dawned the big day. The two brothers took their machine, Flyer I, to the same sandy beach, Kitty Hawk. Both brothers were bachelors because, as Orville said, they couldn't "support a wife as well as an aeroplane".

Orville lay flat on the lower wing ready to guide the machine, while Wilbur started it.

The engine came alive. The propellers spun. The plane shook. It rolled down the beach. Then suddenly it was up in the air. It bobbed up and down. It swayed a little from side to side. But the important thing was that it flew. It flew a distance of 36 metres in 12 seconds before it came down in the sand. They were the most momentous 12 seconds in the history of powered flight.

Man had learnt to fly. First a few hundred feet, then several miles, then across the North Sea, then over the Atlantic Ocean and then round the world.



Puss moth

Flight to Bombay

October 15, 1932. Twenty-nine years after the Wright brothers had created a revolution in the field of transport. At break of day in Karachi, a light single-engined aircraft spinned into life. It swung into the air and took wing almost instantly. It was heading for Bombay.

At the controls was the strapping 28 year-old pilot, J.R.D. Tata. The aircraft he was flying was a Puss Moth, a wooden plane with fabric covering, except for the front portion of the cabin door pillars and the

engine mounts which were of tubular steel.

He carried no passengers, only mail, because his plane was not big enough for both.

Nervous he must have been. But also very very proud. For, as he brought in the plane to land at Juhu, in Bombay, he knew he would be making history. That was the day that changed the face of the Indian sky.

J.R.D. Tata brought to India the adventure of flying; the advantages of this remarkable invention. We've come a long way since. From the Puss Moth, the Leopard Moth, the DH-86, the DH-89 and the Stintson to the more familiar Dakota, Viking, Skymaster, Constellation, Super Constellation, Boeing 707 and now the Boeing 747 and the Airbus. Tata Airlines is now Air India.



Air-India is one of the oldest airlines in the world.

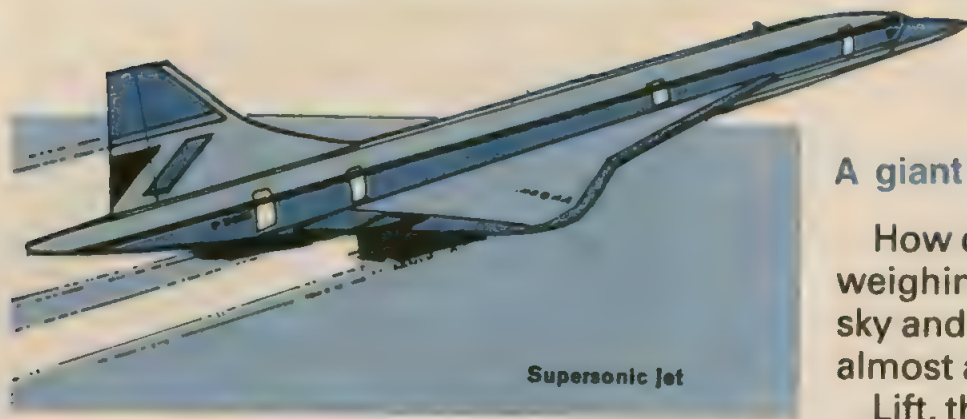
The aeroplane today

In just over eighty years aeroplanes have developed from frail curios to machines we can't do without in the field of transport, communication and defence. Every second one aircraft is taking off or landing somewhere in the world.

In 1927, it took Lindbergh, a 25-year-old American, 33 hours and 29 minutes to fly from New York to Paris. Today we have supersonic transport (SST) that travels twice as fast as the speed of sound and jets across the Atlantic Ocean in just three hours. Flying at a speed of 2150 km/h, it can carry over a hundred people.

Aside from carrying passengers and mail across the world, aeroplanes are also good freight carriers. A single Boeing 747F Jumbo jet can carry as much cargo in a year as was conveyed by all the world's airlines together in 1939.

We also have fighter planes which have



Supersonic Jet

the ability to go 'zang'! This means that the plane will suddenly dart sideways, go straight up or straight down without changing wing or nose position. The Harrier can take-off and land vertically. It can land in rough country without runways, or on the deck of a ship.

These are just some of the recent advances in aviation technology. A new generation of longer winged, fuel efficient jetliners is waiting to take-off.

Thrilling it is. Yet we all seem to take flying for granted today.

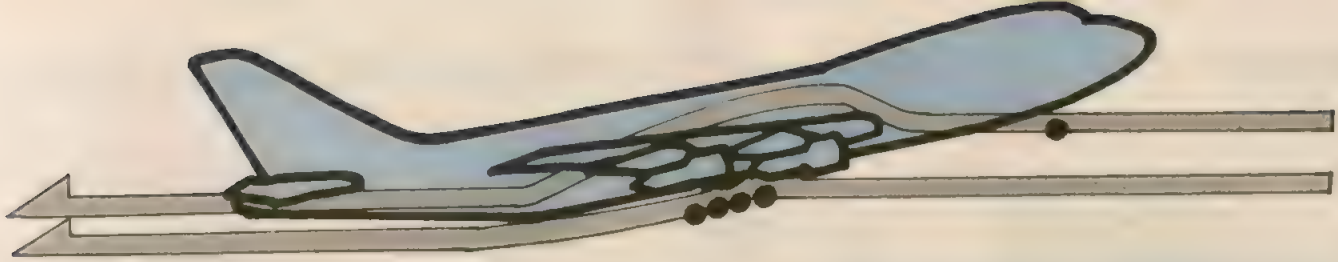
A giant in the sky

How does this huge object, some weighing 320 tons fly so gracefully in the sky and manage to stay up there for so long almost as if it were part of God's creation.

Lift, thrust and drag. These are the fundamentals of flight. All three are invisible, yet this is what man has devoted many, many years to, in order to get an object that is heavier than air up in the clouds.



The world's first airmail flight was flown in India on February 18, 1911, when Mr. Henri Pequet, a Frenchman, carried mail in a Humber bi-plane from Allahabad to Naini Junction, some 9.6 kilometres away.



Flow of air over curved wing (aerofoil) lifts the plane

How does it go up?

Lift—the most important part of flying—comes from the flow of air around the wings of the aeroplane. Lift is what pushes the wing up.

It was a Swiss scientist, Daniel Bernoulli, who discovered that “in any moving fluid the pressure is lowest where the speed is greatest. The air about us acts like a fluid and if we can increase the speed of air over a surface, such as a wing, the pressure should decrease and the wing should rise.”

This principle can be applied to an aeroplane as well.

If you walk up to an aircraft and look at it carefully you’ll notice that the upper surface of the wing is generally curved while the

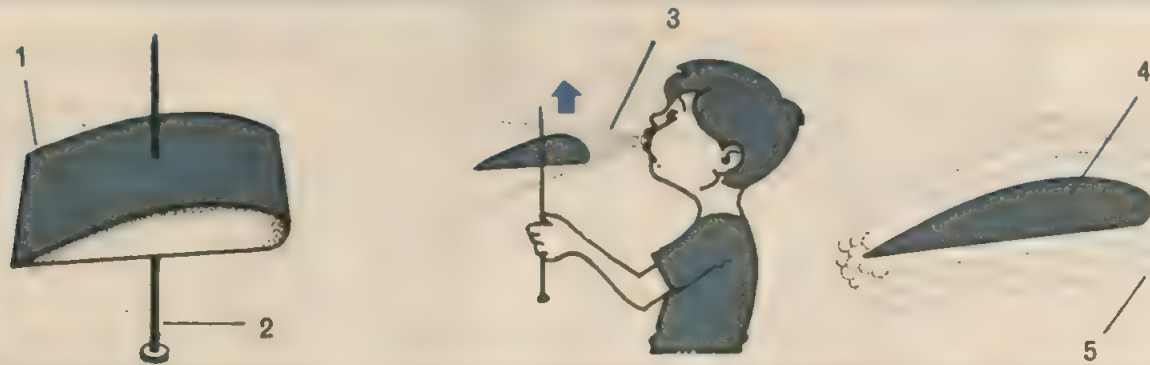
lower part is straight.

Now, if you walk up to a bird—that may not be as easy as walking up to an aircraft—you’ll see that its wings too are curved on top while the bottom is straight.

It is this shape, called the aerofoil, that helps to lift the plane and keep it up. In order to understand why this is so, we have to know a bit about airflow.

The air that goes over the top of the wing will act differently than the air that goes under the wing. As the air has to travel a





1. Paste here 2. Push knitting needle in centre 3. Blow 4. Cross section of a wing 5. Air

greater distance over the top part of the wing, which is curved, it will travel at a faster speed. The air that goes under the wing will flow along a straight line. In travelling farther the layer of air on top of the wing thins out.

All along the top of the wing, therefore, there is low pressure and along the bottom there is a thick layer of air. When there's more air under the wing than on top only one thing can happen. The air underneath pushes the wing up, up and away.

To understand this better here's what you can do. Take a piece of stiff paper about 15

centimetres by 20 centimetres. Roll it over and paste the 15 centimetre ends as shown. Push in a knitting needle in the centre.

Hold the paper up by the knitting needle and blow hard on it. (See diagram) You will find the paper is being pushed up. This is the result of lift caused by the shape of the paper.

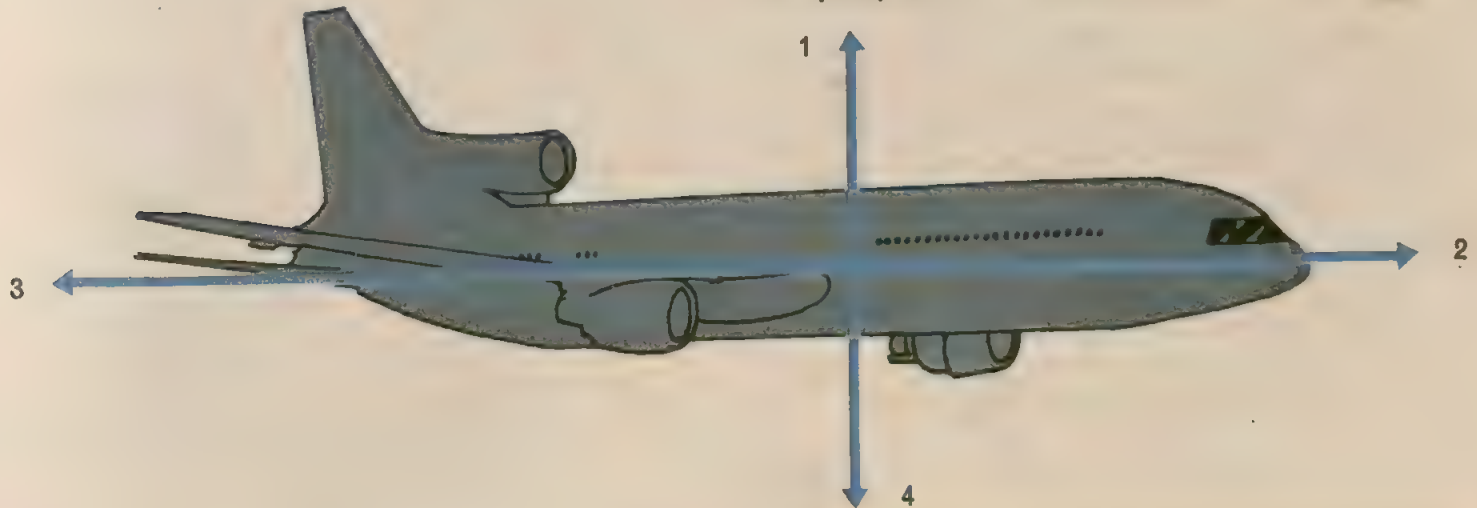
The air that you blow on the paper flows around it. Some of it goes along the lower surface to the back. But some flows on top and then to the back. There is a greater pressure of air underneath and thus the paper is pushed up.

The plane's best friend and worst enemy

Air may seem like nothing, yet it is there. It has force, it has power. It can push. It can pull. It has density. It can act and react.

Without air a plane cannot fly. Yet, if man had not learnt to overcome the 'obstacles' in the air he would not have been able to fly.

1. Lift 2. Thrust 3. Drag 4. Weight



A great big push

A plane is standing on the ground waiting to take-off. There is air all around, but what the plane needs in order to get off the ground, is thrust, or a big push, which creates the necessary flow of air around the wings.

This comes from the engine in a jet aircraft. In a propeller-driven plane, that is a plane with huge fans—the push comes from the propellers.

What a drag

Drag is what the plane has to fight against. It is the resistance an aircraft experiences when passing through the air. To overcome drag, the plane uses thrust.

Every moving object tends to slow down because of drag. It could be the drag of water, the drag of air, or friction on roads or rails. This drag force can also slow down a satellite, until it falls to the ground. Incidentally, studies show that even the moon is affected by drag.

Aircraft today are more streamlined so that there is less resistance from the air.

When thrust and lift are stronger than drag, the plane rises.

Aircraft tyres are filled with nitrogen, not air. This means that there is no oxygen in them. So in case of an accident there is less chance of the tyre catching fire.

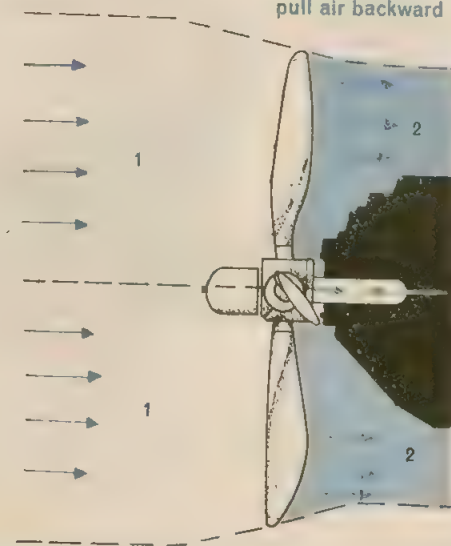


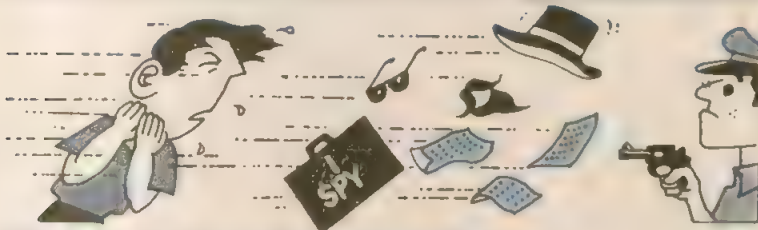
The engine at work

As in motor car, an aircraft needs an engine. The only difference is that an aircraft engine is much bigger and stronger. Often a plane has more than one engine.

Fuel runs the engine of an aeroplane, but unlike a motor car it does not send power to the wheels. Instead it turns the propeller. In a jet the engine works differently, as we will see later.

1. Air Intake 2. Propeller blades pull air backward





Watch-out it's the propeller

The aeroplane propeller is like a big fan. It has blades that are curved. These blades cut through the air, and also pull the air backward. This air then pushes the aeroplane forward.

If you were to be standing behind the plane when the propeller is turning, watch out. You would probably be blown off. So great is the force generated.

Issac Newton worked out how this happens long before the propeller driven plane was invented. He proved that action and reaction are equal and opposite.

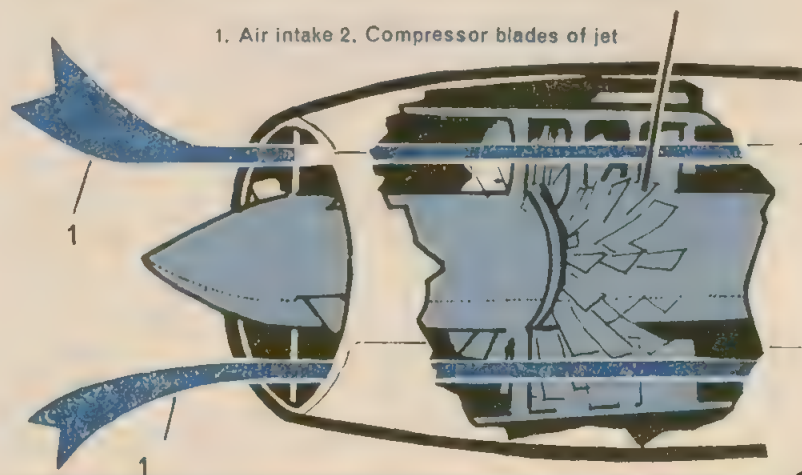
When the propeller pushes air backward it is action. The reaction pushes the propeller forward and being a part of the aeroplane it helps in carrying the plane forward.

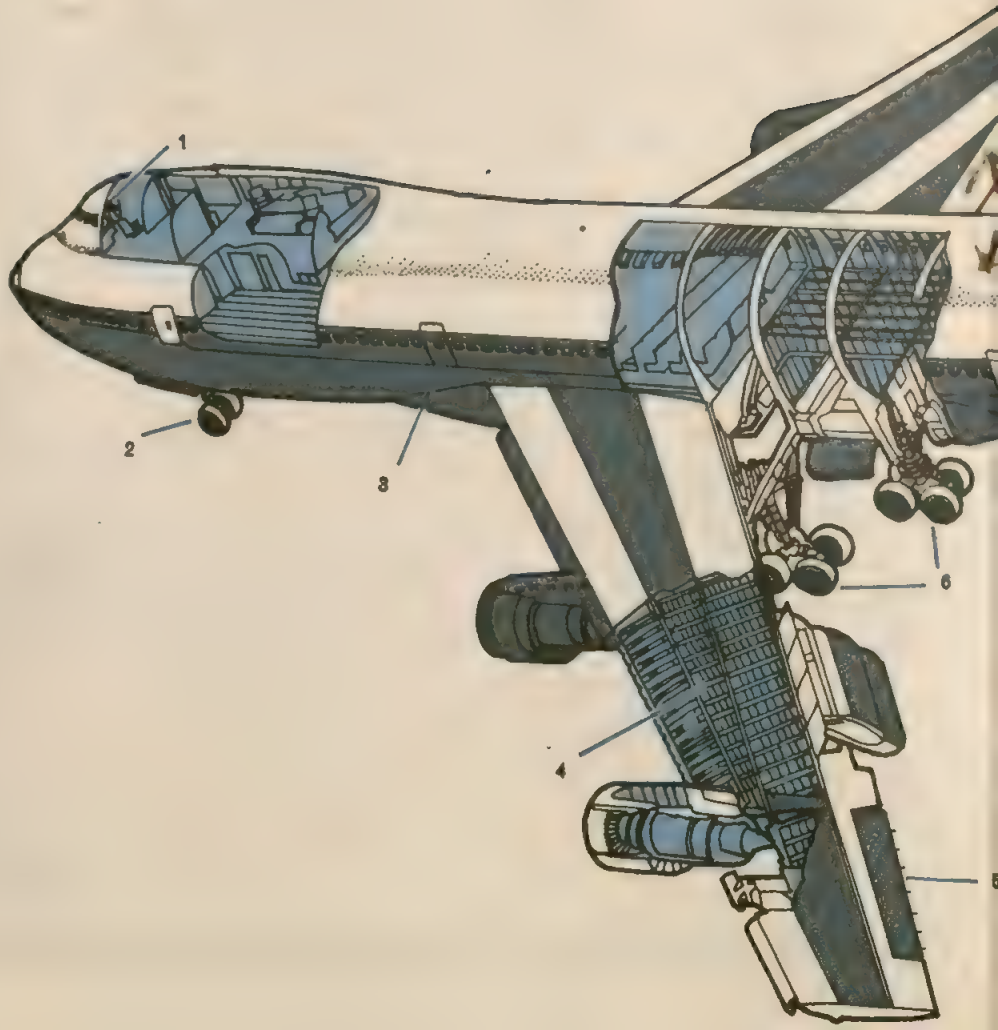
The jet-age

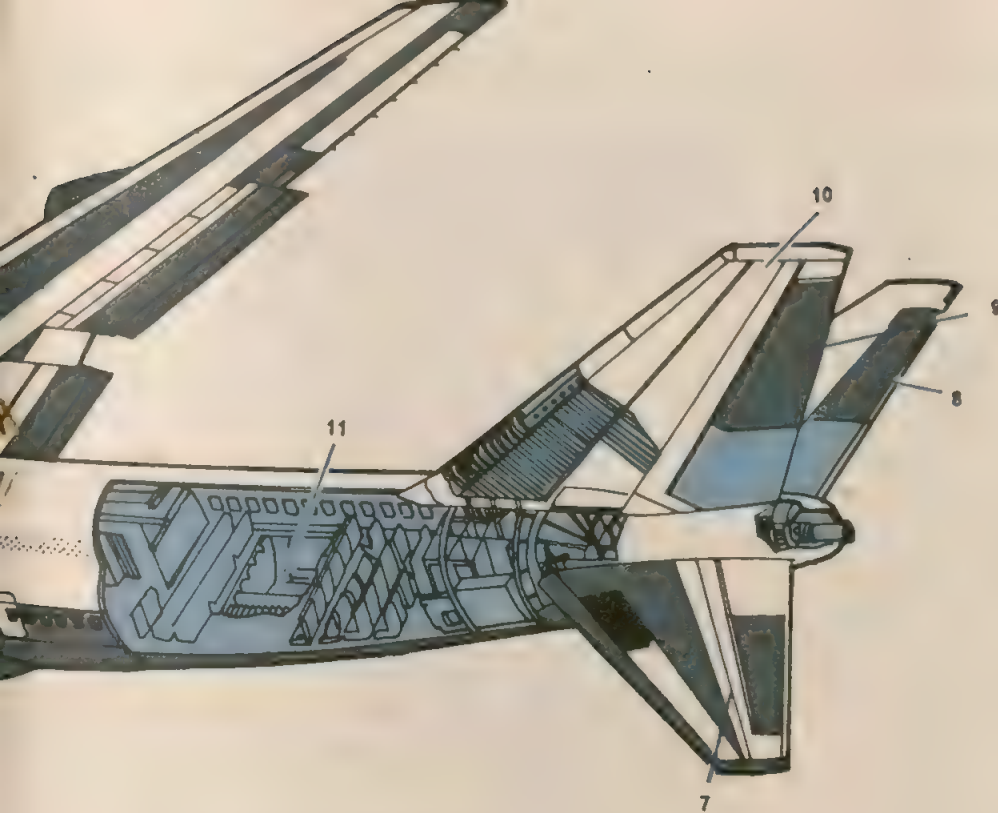
Before the 2nd world war all aeroplanes had propellers. The first planes with jet engines were used in the war.

The jet engine draws in air at the front. This air is forced into a chamber by blades. Here it is mixed with fuel. The mixture burns. The burned gases shoot out from the jet pipe at high speed and whoosh ... the plane shoots forward.

The principle is the same as in a propeller driven plane. There is a force pushing ₂







1. Cockpit 2. Nose wheel 3. Front passenger door 4. Wings
(also serve as fuel tanks) 5. Aileron 6. Under carriage
7. Horizontal stabilizer 8. Elevator 9. Rudder 10. Vertical fin
11. Freight hold (beneath the passenger deck)



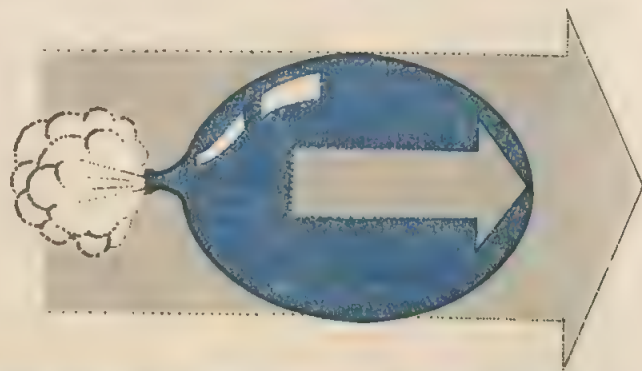
ahead in the jet that is exactly equal to the force of the gases gushing out of the back end.

You can prove this by blowing up a balloon with air as far as it will go. Then hold the end tightly so that no air escapes.

When the balloon is closed the imprisoned air presses the inside of the balloon in all directions. Similarly the balloon presses on the enclosed air with equal pressure and in opposite direction.

When you let go, the air is forced out of the opening. But there is another force, exerted by the air in the balloon upon the

balloon's inner surface. This force is equal to the force pushing the air out, but its direction is opposite. That is why the balloon flies off in the direction opposite to that of the stream of air coming out of the balloon and goes shooting across the room.





The inside story

Now that we know how a plane gets off the ground and are reasonably sure of it staying up there, let us board a Jumbo Jet and see what goes on inside.

At the airport

Boarding a plane by the way is not as easy as getting into a car. And that is why flying is an event for a lot of people even today.

An airport never sleeps. At any time of the day or night it's bustling with activity.

International airports usually have their departure and arrivals separate, so that the passengers don't get mixed up.

When you arrive at an airport you show your ticket and have your baggage weighed first, for you are allowed a limited amount.

International flight passengers must

show their passports to the passport officer. Once all that is clear, you are requested to proceed to a particular gate number for a security check. From here you can either walk straight on to the waiting plane or go by bus if the plane is a long way from the terminal.

A Jumbo jet is so big that the first ever flight by the Wright brothers in 1903 could have been made in the length of its passenger cabin.

Checking-in



Passport Clearance



Security check



To the plane



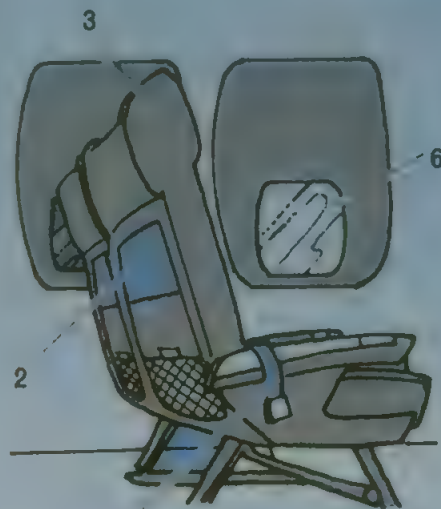
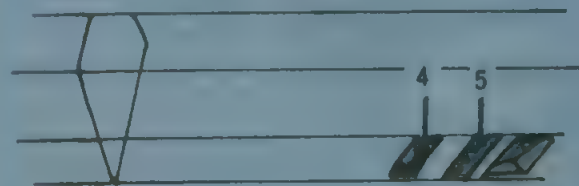
On board

At last you are on board. You are taken to your seat. It's a comfortable armchair which can be straightened when you want to look out of the window and pushed back when you wish to have a nap. A jumbo is known as a 'wide bodied' jet. The passengers sit up to ten abreast. The luggage hold is beneath the passenger deck.



The toilets in an aircraft are expensive because of the complex plumbing system. The power for heating the water has to be taken from a generator whirling at many thousands of revolutions per minute. The flush is electric. The water is taken out by heavy suction and finally streams out of the aircraft in a 933.3 km/h stream. It turns into ice instantly.

1. Seat belt 2. Fold-down table 3. Adjustable seat-back
4. Light 5. Air-vent 6. Window



Acc. no. - 15211



1. Captain's seat 2. Rudder pedals 3. Control column
4. Compass 5. Clock 6. Air speed indicator 7. Radio
altimeter 8. Pressure altimeter 9. Engine switches

The cockpit

Right up in front, in the cockpit, sit the most important people, the captain and the crew.

The pilot checks in 90 minutes before take-off, and goes through the flight plan, that is, maps, checklists, certificates of airworthiness and so on. Most flight plans are now worked out by a computer. The crew then examines the aircraft by taking a walk round it. Among other things like food and drinks for over 300 people, about 159,110 litres of fuel are being pumped into the aircraft.

In the cockpit the pilot's first check is to see that all switches are off. Aircraft switches, unlike other switches, are down for off and up for on.

Then he reads the log-book to see what previous pilots have noted. All pilots keep a diary of every flight, called a log.

There are over 50 pre-flight checks that

the captain and first officer go through one by one. The captain sits in the left hand seat. The first officer or copilot sits on the right and behind them facing sideways is the flight engineer.

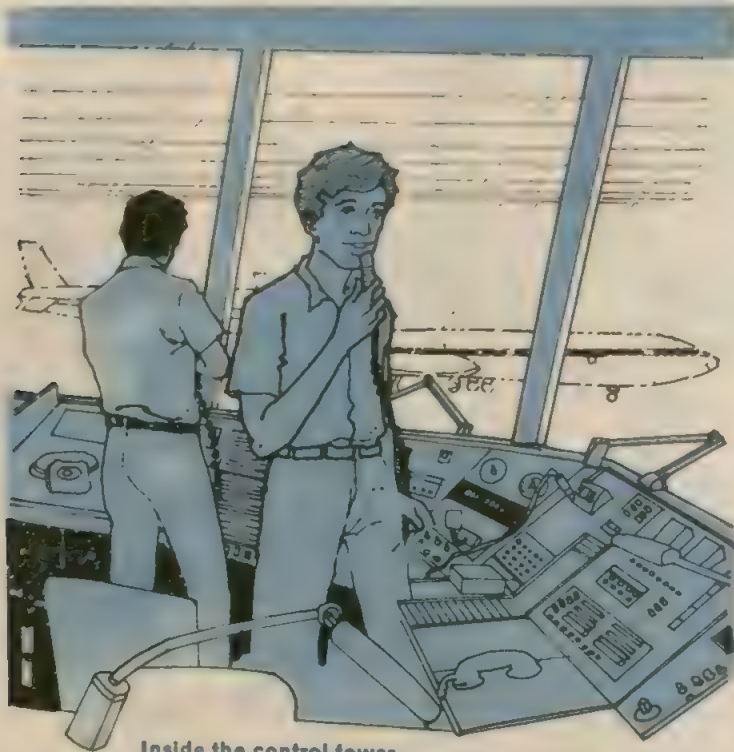
They have before them a mass of dials and instruments which would make anyone's head whirl and you wonder how they can remember what is what when flying the plane. Yet, for a pilot it is the easiest thing in the world.

Some of the important instruments strewn before him include the air-speed indicator which tells you how fast the plane is travelling; the compass which shows the direction the plane is travelling in; the altimeter which tells you how high the plane is from the ground; the attitude gyro which indicates the plane's position in relation to the horizon; the turn-and-bank indicator which tells you whether the plane is flying straight; the vertical-speed indicator which shows the rate at which the



1. The pilot 2. The co-pilot 3. The engineer

plane is climbing or descending in relation to the ground; the chronometer which is a perfectly accurate clock and so on.



Inside the control tower

Fasten your seat-belts

Far across the airfield is a brightly painted tower—a kind of light house for aeroplanes. The men who work inside this control tower

tell the pilot by radio, when to take off and when to land. The captain first asks for permission to move slowly or 'taxi' to the runway.

Then, the engines are started. In a jumbo jet there are four engines. The plane 'taxi' to take-off position.

You fasten your seat belts. The count-down begins.

The captain and the first-officer push the four throttle handles. The throttle helps to increase the speed of the engine.

"V₁" says co-pilot. That is the first speed, V standing for velocity. The plane races down the runway.

In a few seconds the plane reaches VS, (the lift-off speed).

"Rotate," says the co-pilot. The engine now sounds like a 100 lions roaring.

The captain pulls back the control column and the nose lifts off the ground.

"V₂" calls out the co-pilot, the climbing speed, and you're in the air!

You get a funny feeling in your stomach.
Grrr Clunk! The wheels go up. Higher
and higher you go, until automobiles on the
roads look like dinky cars and people like
ants.

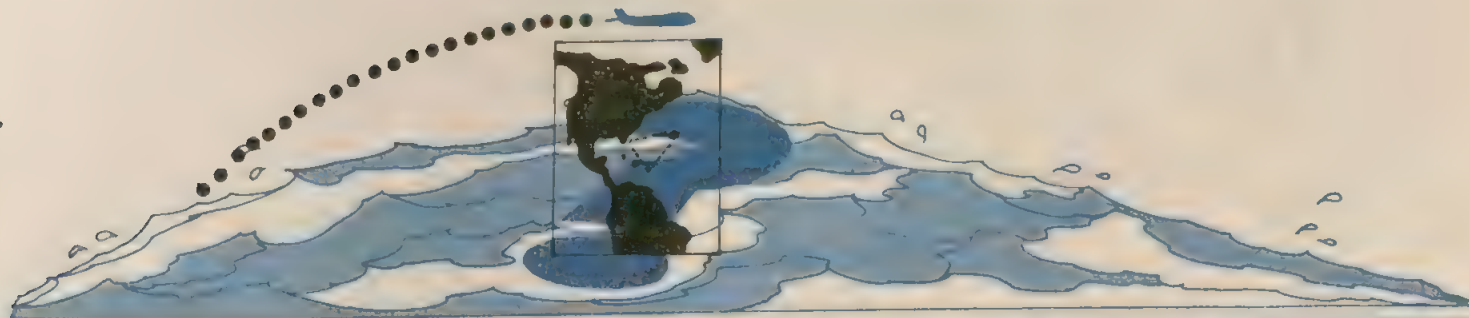
Bubbles pop in your ears. You swallow
and they go away.

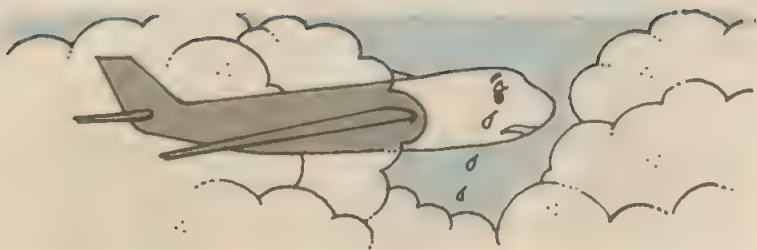
Suddenly you can't see anything. The
plane is in a cloud.

And suddenly it's sunshine again. This
time the plane is above the clouds. It has
become a part of the sky. A different world
which is beautiful and serene.



Some of the smoothest flying in the
world is said to be had over the Arctic. The
most dangerous is said to be in the
'Bermuda Triangle'. Legend has it that
aircraft and ships travelling in the Bermu-
da Triangle are snatched away by an
inexplicable force.





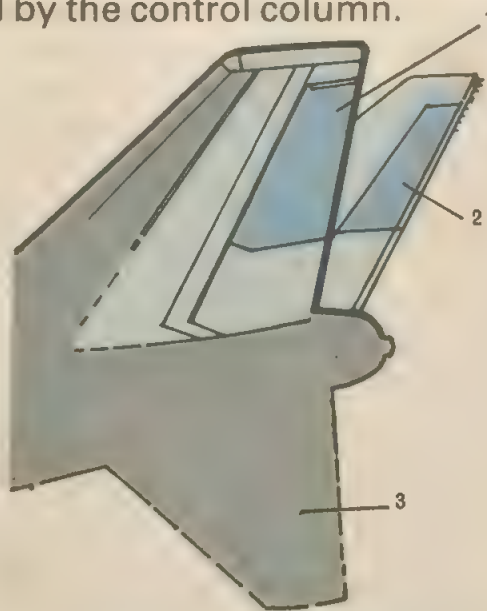
Finding its way

A plane can lose its way just as easily as a car. A single air current is enough to pull the plane off course, and that is why it is so necessary to watch the compass and many other instruments to make sure that the plane is keeping to the right course. Radio contact with special transmitters set up near airports help the most.

Even better are networks of special radio sending stations that have been set up in many parts of the world. A pilot with a radio that can tune in to these stations can tell exactly where he is at any moment of his flight.

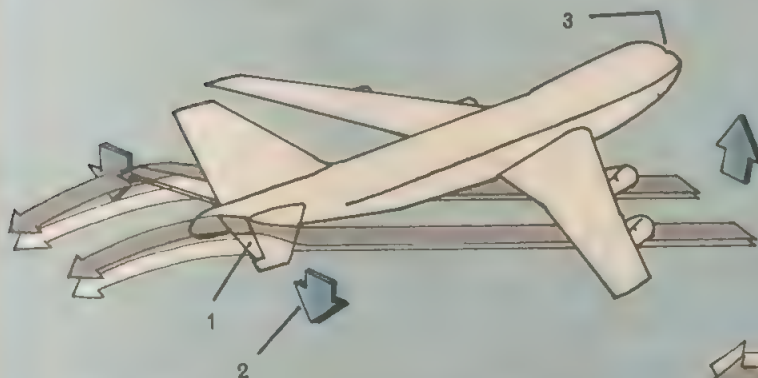
Moving in the blue

A plane can move in almost any direction. It can be tilted up or down, turned right or left. To make this possible certain devices on the edges of the wings and tail are used. These are called control surfaces and they include elevators, rudder and ailerons. They are operated by pedals at the pilot's feet and by the control column.

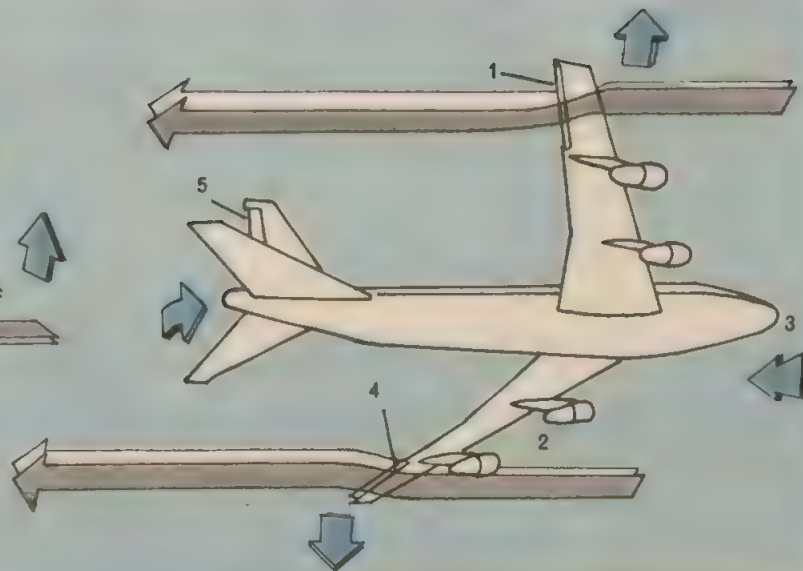


1. Rudder 2. Elevator 3. Horizontal stabilizer

1. Elevator 2. Downward force on tail 3. Nose comes up



1. Aileron down 2. Aileron movements make plane bank
3. Plane banks causing it to turn 4. Aileron up 5. The pilot
moves the rudder slightly to balance the turn.

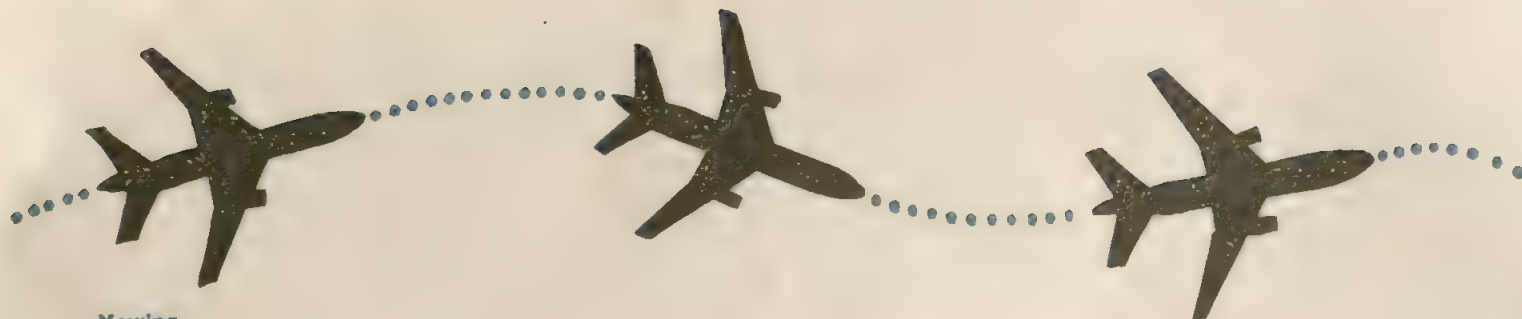


Banana peel in the sky

When the plane's nose swings from left to right it is known as yaw. The long tail, the vertical fin of the plane, has a broad metal movable piece called the rudder.

The pilot has only to press the right pedal at his feet and the rudder moves to the

right. The air rushing past hits the rudder and pushes the tail to the left. This helps to turn the plane to the right. If the pilot didn't use these controls and turned the plane just like that it would skid like a car sometimes does. So you see the sky too has its banana peels!



Yawing

Pitching a plane

When the nose of a plane moves up and down it is known as pitching. This is controlled by elevators—horizontal movable parts of the aeroplane's tail.

To take the plane up the pilot pulls the control column back. This moves the elevators up. Air flowing across the

elevators forces the tail down and nose up. So the plane climbs.

To descend the opposite is done. The pilot pushes the control column. This moves the elevators down. The tail moves up and the nose goes down.

One wrong move on the part of the pilot can lead to disaster.



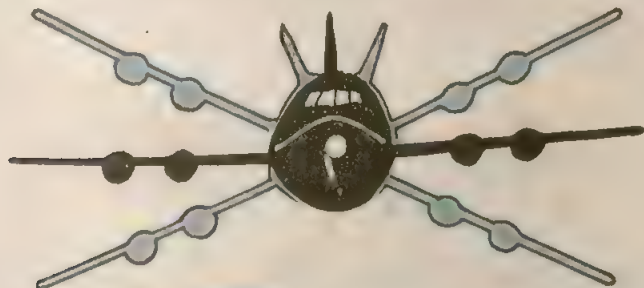
Pitching

Rolling in the air

When one wing goes up or down in relation to the other the plane is said to be rolling.

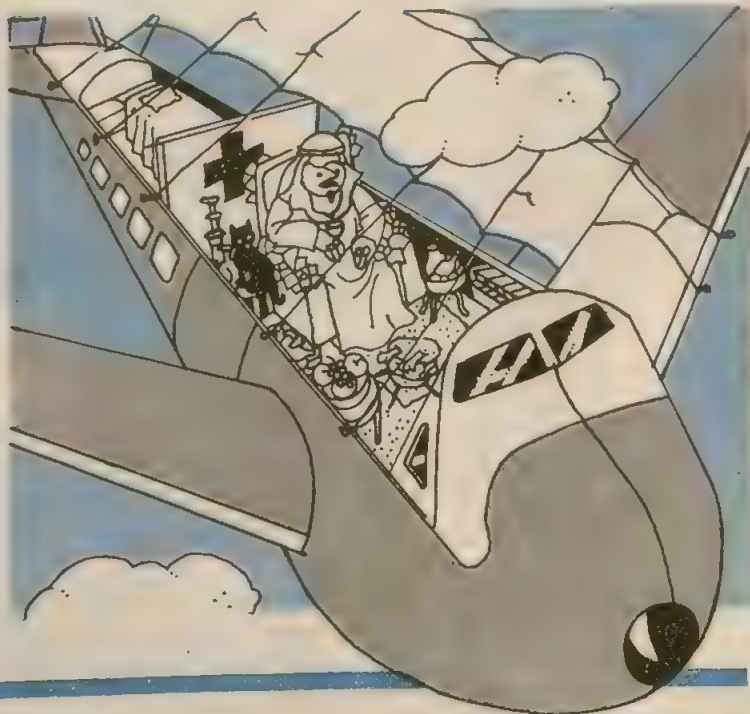
To control this the wings have ailerons. These move in opposite directions. If the right aileron is up the left one will be down. The aircraft will then 'bank' towards the aileron that is up. So if the left aileron is up the plane will not roll to the right.

We've tried to tell you as briefly as possible some of the things involved in flying a plane. It is a highly technical operation and extremely challenging as well. Perhaps one of these days you too will be up there, at the controls.



Rolling

King Khaled of Saudi Arabia has ordered a £21 million 747 executive jet. The plane will have a room with a throne and a hospital section with satellite communications to a hospital in Cleveland.



The journey is over

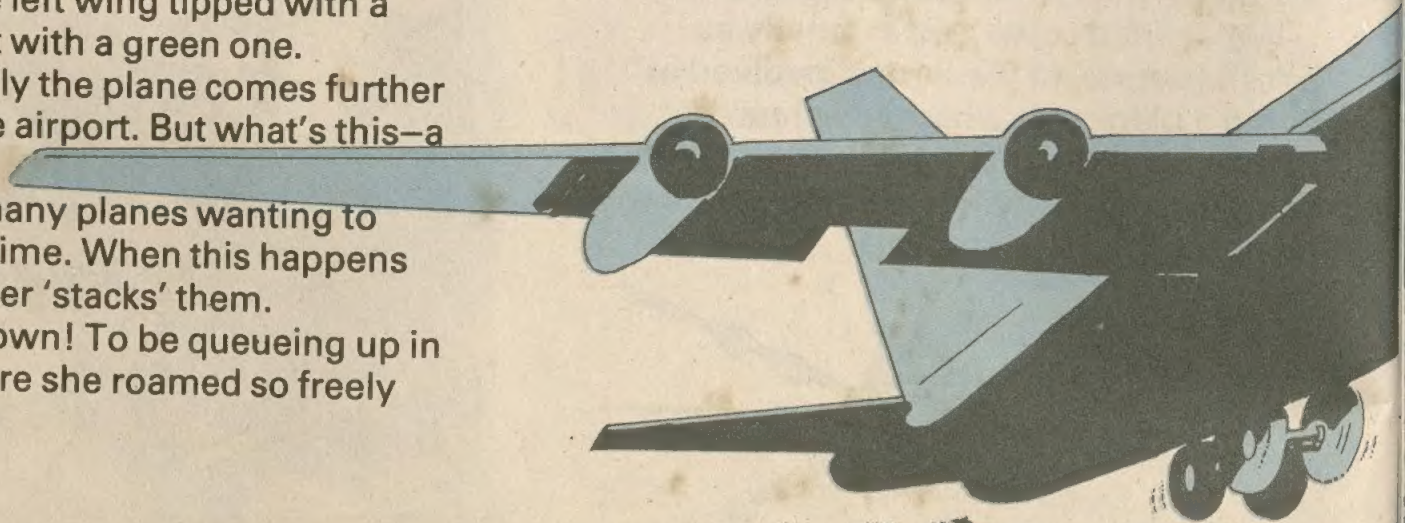
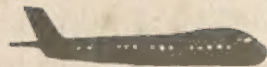
Bejewelled. Sparkling. Twinkling with the stars. Playing hide and seek with the clouds. Almost reluctant to leave the skies she's wedded to—a plane landing at night is a fascinating sight.

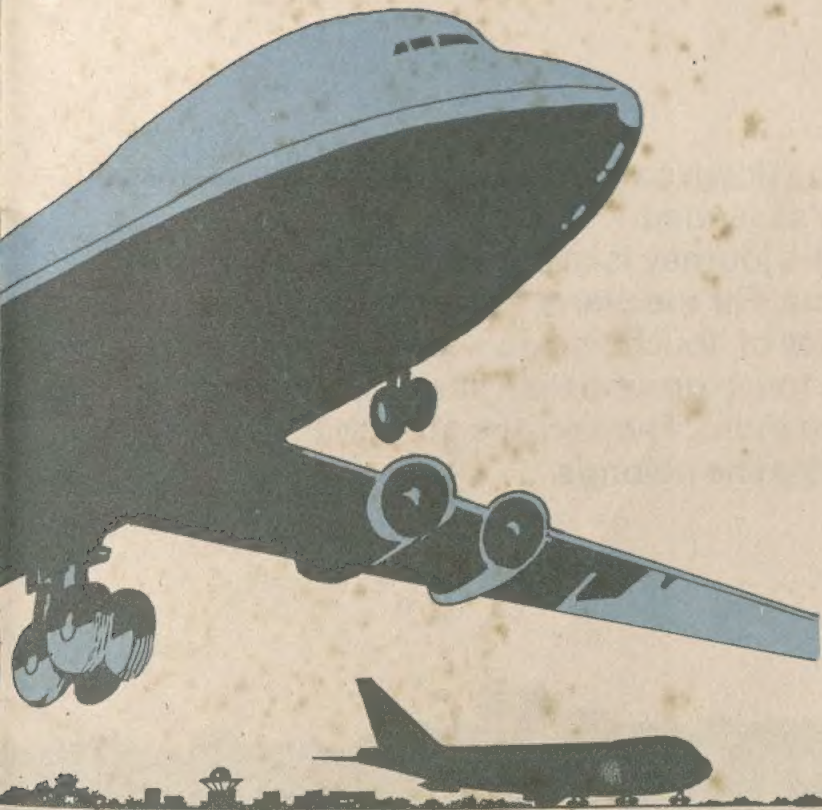
Gently and so gracefully she slopes down the dark skies, the left wing tipped with a red light, the right with a green one.

Slowly but surely the plane comes further down towards the airport. But what's this—a jam in the air!

There are too many planes wanting to land at the same time. When this happens the traffic controller 'stacks' them.

What a come down! To be queueing up in the same sky where she roamed so freely



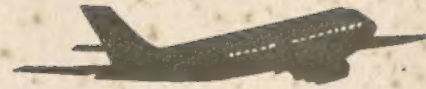


minutes ago.

Starting, from the bottom of the 'stack' the planes are given permission to land one by one.

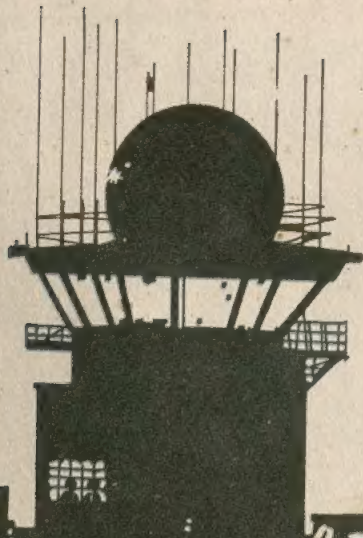
The pilot recognizes his destination by two powerful lights called beacons. Soon the runway lights come into view.

Using control surfaces the pilot brings the



plane down so gently that you barely know you've landed.

The journey is over and soon you're home. For the plane, however, life is a series of 'touch and go's'. No sooner does she touch ground than she is spruced up once more. Then off she goes to the skies where she belongs.



This book, one of a series of information books, introduces the child to the aeroplane. It explains how it flies and how it came to be.

Others in this series include:

- The Telephone
- The Television
- The Motor Car

